(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 May 2001 (17.05.2001)

PCT

(10) International Publication Number
WO 01/35440 A1

(51) International Patent Classification[7]: H01J 37/04, 9/18

(21) International Application Number: PCT/US00/23500

(22) International Filing Date: 25 August 2000 (25.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/437,808 10 November 1999 (10.11.1999) US

(71) Applicant: ETEC SYSTEMS, INC. [US/US]; 26460 Corporate Avenue, Hayward, CA 94545 (US).

(72) Inventors: SPALLAS, James, P.; 8248 H Northlake Drive, Dublin, CA 94568 (US). MURAY, Lawrence, P.; 62 Buckingham Drive, Moraga, CA 94556 (US).

(74) Agents: BERNADICOU, Michael, A. et al.; Blakely, Sokoloff, Taylor & Zafman LLP, 7th floor, 12400 Wilshire Boulevard, Los Angeles, CA 90025 (US).

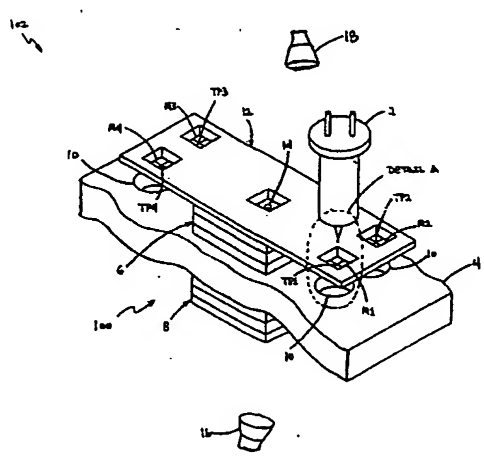
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS FOR ELECTRON BEAM COLUMN ASSEMBLY WITH PRECISE ALIGNMENT USING DISPLACED SEMI-TRANSPARENT MEMBRANES



(57) Abstract: For electron beam columns, an off-axis alignment assembly for aligning an electron beam emitter tip to an aperture and a method of aligning the two. One embodiment of the alignment assembly is made of an electrically conductive material, such as doped silicon, which is formed integrally with an electron beam microcolumn assembly. The alignment assembly has several areas etched down to thin membranes ranging in thickness from about 2 µm to 10 µm. A target (e.g., a hole or raised area) is formed in each membrane and an aperture is formed during the same operation to maintain precise distances between each of the targeting positions and between each targeting position and aperture. Each membrane is transparent to a light illuminating one, or both, of its surfaces, thus allowing direct alignment of an emitting tip of an electron beam emitter with the target. Once this positioning is performed for, e.g., three targets, the precise location of the emitting tip is known relative to the aperture on the alignemt assembly, thus enabling tip alignment to the aperture without directly viewing either the tip or aperture together.

WO 01/35440 A1

METHOD AND APPARATUS FOR ELECTRON BEAM COLUMN ASSEMBLY WITH PRECISE ALIGNMENT USING DISPLACED SEMI-TRANSPARENT MEMBRANES

BACKGROUND

Field of the Invention

This invention relates to electron guns (sources) for use, e.g., in electron beam lithography and specifically to the fabrication of such electron guns.

Description of Related Art

Electron beam columns are well known for use, for instance, in electron beam lithography for imaging a pattern onto a substrate typically coated with a resist sensitive to electron beams. Subsequent development of the exposed resist defines a pattern in the resist which later can be used as a pattern for etching or other processes. Electron beam columns are also used in electron microscopy for imaging surfaces and thin samples. Conventional electron beam columns for electron microscopy and lithography are well known and typically include an electron gun, including an electron emitter, that produces an electron beam. The beam from the gun may be used to produce a scanning probe, or may be used to illuminate a sample or an aperture using a series of electron beam lenses, which are magnetic or electrostatic lenses.

A variant is called a microcolumn which is a very short and small diameter electron beam column typically used in an array of such columns; See "Electron beam microcolumns for lithography and related applications" by T.H.P. Chang, et al., Journal of Vacuum Science Technology Bulletin, 14(6), pp. 3774-3781, Nov/Dec 1996. See also U.S. Patent 5,122,663 to T.H.P. Chang, et al., issued June 16, 1992, also describing microcolumns. These documents are incorporated herein by reference.

Both conventional electron beam columns and microcolumns include a source of electrons. In one version this source is a conventional Schottky emission gun (emitter) or a field emission gun (both are generally referred to as electron guns) which typically includes an emitter (cathode) and the triode region surrounding the emitter downstream of which, with respect to the direction of the electron beam, is an electrostatic pre-accelerator lens that focuses and accelerates the electron beam to its final energy. As described above, this gun "optics" is followed by a series of "lenses" which refocuses and images the source aperture or sample onto the target. (These are electrostatic or electromagnetic elements, not light optics.)

An important requirement for microcolumn operation is the accurate alignment of the emitter tip to the center of the aperture, e.g., an extractor aperture. Such apertures can have a diameter of 5 µm or less, thus making precision alignments very difficult. Another difficulty in emitter to aperture alignment arises from the microcolumn geometry which prohibits the simultaneous viewing of the emitter tip and aperture. A current method conventionally known in the art for aligning the emitter tip to the aperture center during electron gun assembly involves recording a digitized image of the aperture with a conventional digital camera and electronically placing cross hairs at an alignment target at some point on the image. Another point on the backside of the emitter assembly (typically the center point of the filament posts) is then aligned to the cross hairs on the digitized aperture image. Additionally, during operating conditions thermal expansion of the components within the emitter displaces the tip. This additional offset further complicates aligning the target to the digitized cross hairs. Furthermore, because this method depends upon a static digitized image, any physical shifting of the system after the image is captured will cause a tip misalignment.

SUMMARY

In accordance with the invention, an off-axis alignment assembly for aligning an electron beam emitter tip to an aperture is described and a method for aligning the two is also described for use during electron beam column assembly.

One embodiment in an electron beam column of the alignment assembly is made of an electrically conductive material which is formed integrally with a microcolumn assembly. This alignment assembly is, e.g., a wafer of silicon, having several areas etched down to thin membranes ranging in thickness from about 2 μm to 10 μm. Conventional electron beam or optical lithography defines an aperture in the alignment assembly and targeting positions (holes) in each of the membranes during the same operation so that precise distances between each of the targeting positions and between each targeting position and aperture are maintained.

The alignment assembly may be integrally formed with a microcolumn assembly within the electron source assembly or possibly with the Einzel lens but it is formed so that the aperture on the assembly is aligned with a targeted aperture within the microcolumn and the targeting membranes are off-axis of the aperture and outside the source assembly and Einzel lens columns. An electron beam emitter is then positioned over one of the membranes and viewed with a conventional (light) imaging camera from beneath the membrane and the microcolumn base through a viewing hole in the base. A method of alignment involves first directing the light beneath the membrane onto the membrane surface so that the targeting position can be located on the membrane surface. The second light above the membrane is then used to illuminate its opposite surface, thereby making it largely transparent (transmissive) when viewed from beneath. The tip of the emitter can be seen through the transmissive membrane and moved so it becomes aligned with the targeting position on the membrane. An alternative method of alignment involves simultaneously providing a light beneath the membrane and a second light above the membrane; this allows simultaneous super-imposed viewing of both the targeting position on the membrane and the emitter tip seen through the transmissive membrane. The emitter tip can then be aligned with the target and the tip position recorded. Once this is done, the electron beam emitter is moved to another targeting position on a second membrane and the same procedure is repeated. This is performed for three separate targeting positions. Once completed, the exact position of the emitting tip relative to the targeting positions and aperture is known and can then be aligned with great accuracy.

These embodiments and techniques also allow alignment of the emitter tip to aperture after microcolumn assembly.

Another embodiment has the membranes and targeting positions formed directly into the uppermost layer of the source assembly. This requires having viewing holes extending beneath each of the membranes through the source stack and the microcolumn base so emitting tip alignment can be done prior to assembling the microcolumn assembly with the attachment of the Einzel lens. A second method involves providing the viewing holes through the source stack, microcolumn base, and also the Einzel lens. These additional embodiments also allow emitting tip alignment after the assembly of the microcolumn as well as consuming the least surface area of the microcolumn base in forming arrays of microcolumn assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of the present alignment assembly formed on top of a microcolumn assembly at the extractor aperture.

Figure 2A is a bottom view of Detail A taken from Figure 1. The bottom surface is illuminated with a light and appears opaque; also shown is the targeting position on the membrane surface.

Figure 2B is the same view as in Figure 2A, but with the opposite surface of the membrane illuminated. The membrane appears transparent and reveals the electron beam emitter and emitting tip on the opposite side.

Figure 2C is the same view as in Figures 2A and 2B, but with both surfaces of the membrane illuminated. The membrane appears semi-transparent and reveals both the emitting tip and the targeting position.

Figure 3 is a perspective view of the alignment assembly formed between the source stack and microcolumn base with alignment to the limiting aperture.

Figure 4 is a perspective view of the chip scale alignment targets formed integrally with the source stack and the Einzel assembly.

Figure 5A is a cross-sectional view A-A taken from Figure 4. The cross-section shows the membranes formed on the top layer of the source stack and the viewing holes within the source stack and microcolumn base.

Figure 5B is the same view as in Figure 5A, but with additional viewing holes formed within the Einzel lens assembly.

Use of the same reference symbols in different figures indicates similar or identical items.

DETAILED DESCRIPTION

Figure 1 shows a perspective view of an embodiment of alignment assembly 12 integrated with otherwise conventional microcolumn assembly 100. In this embodiment alignment assembly 12 is used with a microcolumn, but this is illustrative and is not meant to preclude other uses. Described below is an apparatus and a process used for an intermediate alignment procedure in aligning electron beam emitter 2 to a microcolumn assembly. Alignment assembly 12 is of an electrically conductive material, e.g., heavily doped silicon, with a thickness dependent on the microcolumn application and geometry. Additionally, materials such as silicon nitride, Si_3N_4, may also be used to fabricate alignment assembly 12 for applications that do not require conductive membranes. Having alignment assembly 12 made of such materials enables it to be formed as an integral part of microcolumn assembly 100.

Alignment assembly 12 has several regions which have been etched into the material by conventional electron beam or optical lithographic methods at predetermined locations. This etching reduces portions of alignment assembly 12 to thin membrane layers ranging in thickness from about 2 µm to 10 µm as seen in first, second, third, and fourth membranes M1, M2, M3, M4, respectively. Although membrane thickness may vary over the range, in one embodiment the membranes are 3 µm thick, and alignment assembly 12 has three membranes located on its surface for purposes of alignment, as explained in greater detail below. Once each of membranes M1 to M4 have been formed, a targeting location, e.g., a circle, is etched through each membrane by electron beam or

optical lithographic methods to define first target TP1 on first membrane M1. second target TP2 on second membrane M2. third target TP3 on third membrane M3. fourth target TP4 on fourth membrane M4. and so on for N number of membranes. Meanwhile. an aperture. e.g.. extractor aperture 14. having a diameter of about 5 μm is also etched through alignment assembly 12. Targets TP1 to TP4 and extractor aperture 14 are fabricated by conventional lithography methods during a single operation to maintain accurate spacing between each of targets TP1 to TP4 and extractor aperture 14. Alternatively. a single membrane M1 may be etched and a single target TP1 formed rather than a plurality of membranes and targets. Such a process is able to locate the center of extractor aperture 14 relative to each of targets TP1 to TP4 to within an accuracy of about 2.5 nm.

In another embodiment; targets TP1 to TP4 are locations having a thicker cross section than the surrounding portion of the respective membrane.

Once targets TP1 to TP4 and extractor aperture 14 have been formed in alignment assembly 12, it is then integrated with microcolumn assembly 100. Alignment assembly 12 may be placed in various locations within microcolumn assembly 100, but in one embodiment it is located on top of and integrally with source assembly (stack) 6, as seen in Figure 1. to form extractor aperture alignment assembly 102. Alignment assembly 12 thereby becomes a permanent part of the microcolumn structure. For a description of microcolumn fabrication using silicon wafers, see "Electron beam microcolumns for lithography and related applications" by T.H.P. Chang, et al., referenced above. Microcolumn assembly 100 includes. as is well known in the art, source stack 6, Einzel lens 8, microcolumn base 4, and electron beam emitter 2, which is a Schottky emitter in one embodiment. Correctly aligning emitting tip 2T, the tip at which electrons exit the emitter, of electron beam emitter 2 to aperture 14 involves visually aligning them. This is accomplished by providing viewing holes 10 drilled (or formed by any other conventional method) into microcolumn base 4 at locations directly beneath each membrane M1 to M4. The actual alignment involves moving either electron beam emitter 2 or microcolumn assembly 100 with, e.g., conventional precision stages, to first align the body of electron beam emitter 2 with first membrane M1. A

conventional video camera (camera is not shown) mounted below microcolumn base 4 is then used to view the bottom side of first membrane M1 through viewing hole 10. Also mounted beneath microcolumn base 4 is first light source 16, which can be any white light source such as, e.g., a light pipe. First light source 16 illuminates the bottom surface of first membrane M1 giving the surface an opaque appearance, as seen in Figure 2A, which is a bottom view of Detail A taken from Figure 1. The opaque appearance allows first target TP1 to become visible to the camera. Once first target TP1 is located, second light source 18, which can also be any white light source such as, e.g., a ring lamp, is used to illuminate the top surface of first membrane M1. First light source 16 is then turned off. First membrane M1 appears transparent when viewed from below through viewing hole 10 in Figure 2B, which is the same view as Figure 2A but with first membrane M1 illuminated from its top surface. The transparent first membrane M1 also reveals emitting tip 2T and the bottom side of electron beam emitter 2.

An alternative aligning method involves directing light from first light source 16 onto the bottom surface of first membrane M1 and directing light from second light source 18 simultaneously onto the top surface of first membrane M1. As shown in Figure 2C, which is the same view as Figures 2A and 2B, using both first and second light sources 16,18, respectively, makes first membrane M1 appear semi-transparent and allows the simultaneous viewing of both first target TP1 and emitting tip 2T on the bottom side of electron beam emitter 2.

Once emitting tip 2T is located, electron beam emitter 2 or extractor aperture alignment assembly 102 is positioned to superimpose first target TP1 with emitting tip 2T. Once the two are aligned, the position is conventionally recorded and then electron beam emitter 2 is positioned over second membrane M2 and the above described procedure of illuminating opposite membrane surfaces and then superimposing targets with emitting tip 2T is repeated. An alternative embodiment uses only a single target TP1 disposed on a single membrane M1 to align emitting tip 2T to extractor aperture 14 by the above procedure, with perhaps some loss of accuracy.

Alignment assembly 12 may have N number of membrane surfaces, and this procedure is repeated for at least three different membranes M1 to M4 and targets TP1 to TP4. Having finished the targeting procedure and recorded their respective locations, the precise position of emitting tip 2T and electron beam emitter 2 is known relative to the position of extractor aperture 14. Emitting tip 2T may then be positioned directly over extractor aperture 14 without the need for digitizing any images or directly viewing emitting tip 2T relative to extractor aperture 14. Once electron beam emitter 2 is properly aligned, it is fastened in place by conventional methods used in fabricating microcolumns. This method of off-axis aligning greatly increases tip 2T to aperture 14 alignment by allowing direct visual alignment as well as limiting electron beam emitter 2 motion to the X-Y plane, which is defined as the plane coplanar with microcolumn base 4.

The alignment of emitting tip 2T to extractor aperture 14 may require additional adjustments. Electron beam emitters 2 are often tested under varying thermal conditions prior to installation. Also, operating such emitters 2 often causes large temperature swings and this may cause emitting tip 2T to become displaced slightly relative to the position of emitter 2 because of the thermal expansion of materials within emitter 2. Once the displacement of emitting tip 2T is obtained, electron beam emitter 2 can be offset by this value after emitting tip 2T has been aligned with extractor aperture 14. Thus, once microcolumn assembly 100 begins operations, emitting tip 2T will displace accordingly and move into alignment with extractor aperture 14.

In another embodiment, limiting aperture alignment assembly 104 is shown in Figure 3. Figure 3 is similar in most respects to assembly 102 of Figure 1 (in a similar view) with similar elements identically labeled with the exception of alignment assembly 12 which is located between source stack 6 and microcolumn base 4. In Figure 3 viewing holes 10 are hidden by alignment assembly 12 but are present to give a view of the bottom surfaces of membranes M1 to M4. This embodiment is more structurally stable than assembly 102 because alignment assembly 12 is adjacent to microcolumn base 4. The alignment procedure is the

same as for assembly 102, except that emitting tip 2T can now be more easily aligned with the limiting aperture (not shown) within microcolumn assembly 100.

It is also within the scope of this invention to have an embodiment similar to assembly 104 where alignment assembly 12 is formed integral to Einzel lens 8 (this particular embodiment is not shown). This embodiment is similar in most respects to assembly 104, except that alignment assembly 12 is formed atop Einzel lens 8 and placed in between the top of Einzel lens 8 and the bottom surface of microcolumn base 4. The alignment procedure would remain similar to that of assemblies 102 and 104.

Figure 4 shows yet another embodiment with chip scale alignment assembly 106. In this embodiment, rather than utilizing alignment assembly 12, the membranes and their corresponding targets are etched directly into the top layer of source stack 6. The membranes are seen in Figure 4 as first, second, third, and fourth chip membranes CM1, CM2, CM3, CM4, respectively, and the targets located on each corresponding chip membrane are seen as first, second, third, and fourth chip targets CT1, CT2, CT3, CT4, respectively. In order to view chip targets CT1 to CT4 from below, two methods can be utilized.

The first method involves forming the individual layers of source stack 6 with vias extending through its length beneath each of chip membranes CM1 to CM4. Cross-sectional view A-A in Figure 5A, taken from Figure 4, shows source stack vias 20 beneath first and fourth chip membranes CM1, CM4, respectively. Viewing holes 10 have also been formed beneath each of their respective chip membranes CM1 to CM4. This allows the alignment of electron beam emitter 2 to chip targets CT1 to CT4 in much the same manner as described for extractor aperture assembly 102. Once electron beam emitter 2 has been aligned to an aperture, Einzel lens 8 can then be attached to complete microcolumn assembly 100.

The second method is similar to the first, but it involves forming additional vias within Einzel lens 8. Cross-sectional view A-A in Figure 5B is similar to Figure 5A but includes Einzel lens vias 22. Vias 22 are formed collinear to and beneath source stack vias 20 and can be formed during the fabrication of Einzel

lens 8. Source stack and Einzel lens vias 20, 22, respectively, allow the alignment of emitting tip 2T to the chip aperture after the fabrication of microcolumn assembly 100. Chip scale alignment assembly 106 may conserve the most surface area of microcolumn assembly 100 foot print.

Although the invention has been described with reference to particular embodiments, the description is only an example of the invention's application and should not be taken as a limitation. In particular, even though much of preceding discussion was aimed at microcolumn applications, alternative embodiments of this invention include full-scale electron beam applications, variable numbers of membranes, and variable membrane locations off-axis of the aligning aperture. Various other adaptations and combinations of features of the embodiments disclosed are within the scope of the invention as defined by the following claims.

CLAIMS

We claim:

1. A microcolumn assembly, comprising:

a first base;

an electron beam emitter mounted adjacent said first base:

a source stack defining a first aperture and disposed between said first base and said electron beam emitter:

a lens defining a second aperture and disposed adjacent said first base such that said first and said second apertures are coaxial: and

an alignment structure disposed between said lens and said electron beam emitter, comprising:

a second base:

a third aperture defined through said second base and coaxial with said first and second apertures;

at least one membrane defined in said second base, said membrane being thinner than a surrounding portion of said base;

a target in said membrane at a predetermined location: and

wherein said first base further defines an opening coaxial to said membrane.

2. The microcolumn assembly of Claim 1, wherein a first surface of said membrane is opaque to a first light incident thereon and a second opposing surface of said membrane is transmissive of a second light incident thereon.

3. The microcolumn assembly of Claim 1, wherein said target is a hole in said membrane.

4. The microcolumn assembly of Claim 1, wherein said target is thicker than a surrounding portion of said membrane.

5. The microcolumn assembly of Claim 1, wherein said membrane is of non-uniform thickness.

6. The microcolumn assembly of Claim 3, wherein said hole is circular.

7. The microcolumn assembly of Claim 1, wherein said second base is of an electrically conductive material.

8. The microcolumn assembly of Claim 7, wherein said electrically conductive material is doped silicon.

9. The microcolumn assembly of Claim 1, wherein said second base is of silicon nitride.

10. The microcolumn assembly of Claim 1, wherein said membrane is monolithic with said second base.

11. The microcolumn assembly of Claim 1, wherein said membrane has a thickness in a range of about 2 μm to 10 μm.

12. The microcolumn assembly of Claim 1, wherein said third aperture has a diameter of about 5 μm.

13. The microcolumn assembly of Claim 1, wherein said alignment structure is disposed on said source stack.

14. The microcolumn assembly of Claim 1, wherein said alignment structure is disposed between said source stack and said first base.

15. The microcolumn assembly of Claim 1, wherein said alignment structure is disposed between said lens and said first base.

16. The microcolumn assembly of Claim 1, comprising a plurality of said membranes, each having an associated target.

17. The microcolumn assembly of Claim 1, wherein there are at least three said membranes.

18. A microcolumn assembly, comprising:

a base;

an electron beam emitter mounted adjacent said base;

a source stack defining an aperture and disposed between said base and said electron beam emitter, wherein said source stack comprises multiple layers, a layer immediately adjacent said electron beam emitter defining at least one membrane thinner than a surrounding portion of said layer;

said source stack further defining a through hole coaxial to said membrane;

said base further defining a hole coaxial to said membrane; and

a lens disposed adjacent said base such that said lens and said source stack are coaxial.

19. The microcolumn assembly of Claim 18, wherein a first surface of said membrane is opaque to a first light and an opposing second surface is transmissive to a second light.

20. The microcolumn assembly of Claim 18, wherein said membrane has a thickness in a range of about 2 μm to 10 μm.

21. The microcolumn assembly of Claim 18, wherein said an aperture has a diameter of about 5 µm.

22. The microcolumn assembly of Claim 18, wherein said lens further defines a through hole coaxial to said membrane.

23. A method of aligning an electron beam emitter to an aperture for assembling an electron beam column, comprising the acts of:

providing an alignment structure;

moving a target on said alignment structure under said electron beam emitter, whereby said target is a predetermined distance from and coplanar to said aperture;

while maintaining said target under said electron beam emitter, illuminating a first surface of said alignment structure with a first light such that at least a portion of said alignment structure is opaque;

while illuminating said first surface, locating said target;

illuminating a second opposing surface opposite of said first surface with a second light such that at least a portion of said alignment structure is transmissive;

while illuminating said second surface, locating an emitting tip of said column beneath said electron beam emitter and moving said target such that said emitting tip is coaxial to said target;

determining a position of said emitting tip relative to said target; and

displacing said aperture relative to said emitting tip.

24. The method of Claim 23, further comprising repeating said acts of moving through determining for a plurality of targets on said alignment structure.

25. The method of Claim 23, wherein said target is circular.

26. The method of Claim 24, wherein there are at least three targets in said alignment structure.

27. The method of Claim 23, wherein said act of displacing includes displacing said emitting tip relative to said aperture by a predetermined distance.

28. The method of Claim 23, wherein said target is disposed on a portion of said alignment structure thinner than a surrounding portion.

29. An alignment structure for assembly of an electron beam source, comprising:

a base of a heavily doped crystalline material;

an aperture defined through said base;

at least one membrane defined in said base, each said membrane being thinner than a surrounding portion of said base, wherein a first and an opposing second surface of each said membrane are transmissive to a first light incident on said first surface when a second light is incident on said second surface on each of said membrane; and

a target at a predetermined location in each said membrane.

30. The alignment structure of Claim 29, wherein said target is a hole.

31. The alignment structure of Claim 30, wherein said hole is circular.

32. The alignment structure of Claim 29, wherein said target is thicker than a surrounding portion of said membrane.

33. The alignment structure of Claim 29, comprising a plurality of said membranes, each having an associated target.

34. A method of aligning an electron beam emitter to an aperture for assembling on an electron beam column, comprising the acts of:

providing an alignment structure;

moving a target on said alignment structure under said electron beam emitter, wherein said target is a predetermined distance from and coplanar to said aperture;

while maintaining said target under said electron beam emitter, illuminating a first surface of said alignment structure with a first light;

while illuminating said first surface, illuminating a second opposing surface opposite of said first surface with a second light such that at least a portion of said alignment structure is transmissive;

while illuminating said first and second surfaces, locating said target;

while locating said target, locating an emitting tip beneath said electron beam emitter and moving said target such that said emitting tip is coaxial to said target;

determining a position of said emitting tip relative to said target; and

displacing said aperture relative to said emitting tip.

35. The method of Claim 34, further comprising repeating said acts of moving through determining for each of a plurality of targets on said alignment structure.

36. The method of Claim 35, wherein there are at least three said targets.

37. The method of Claim 34, wherein said act of displacing includes displacing said emitting tip relative to said aperture by a predetermined distance.

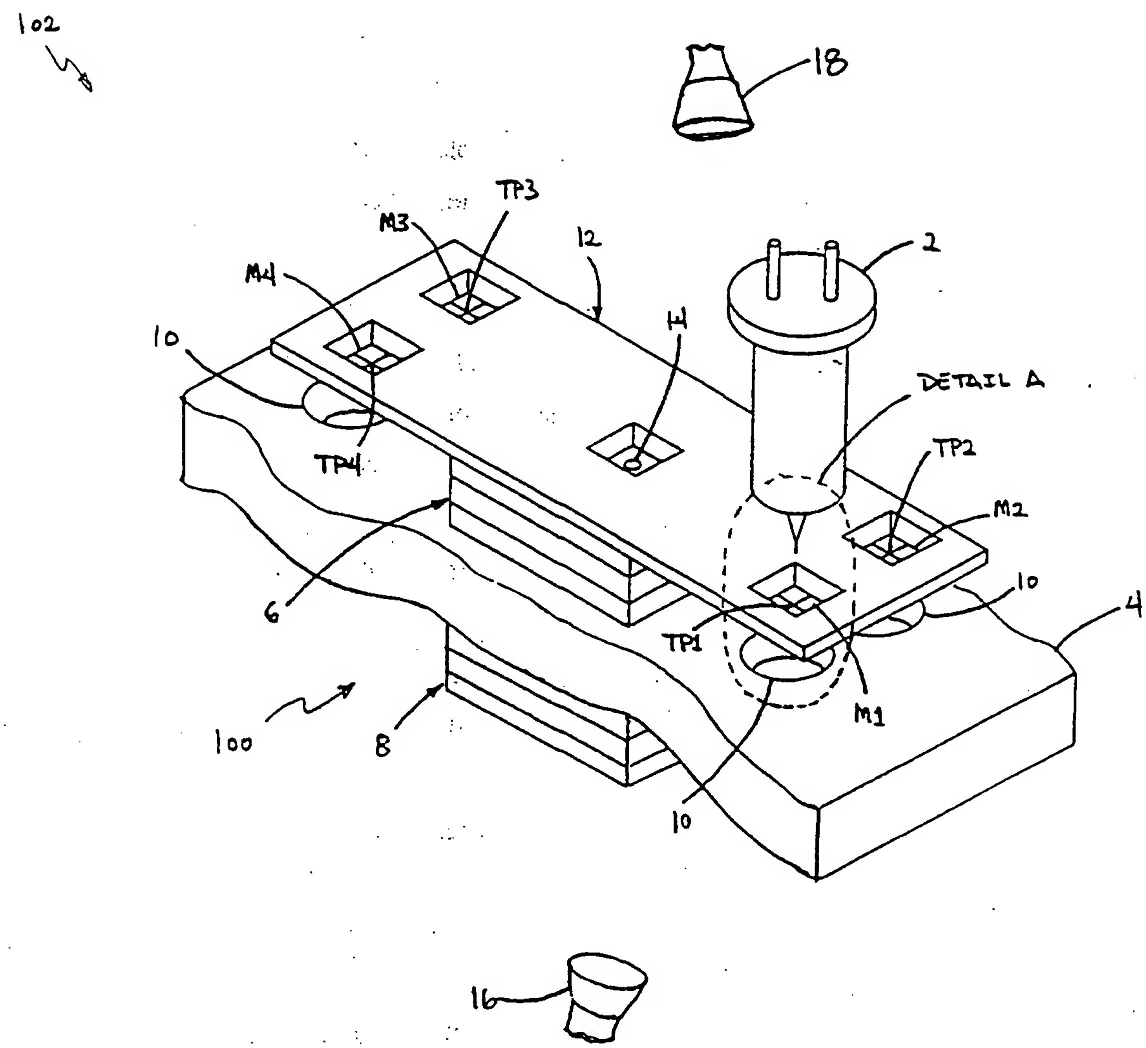

102
18
TP3
M3
12
2
M4
10
H
DETAIL A
TP4
TP2
M2
6
10
TP1
4
100
8
M1
10
16

FIGURE 1

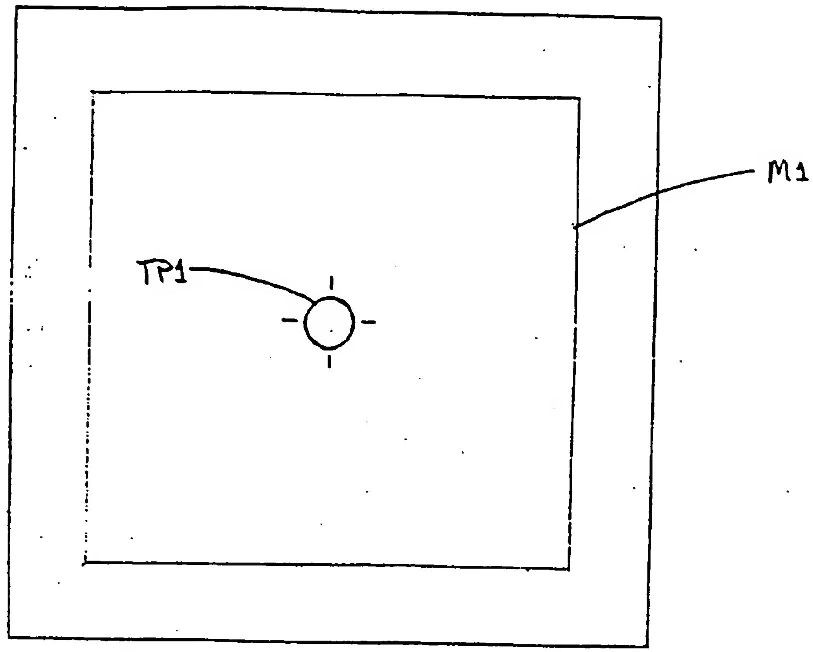


FIGURE 2A
(DETAIL A)

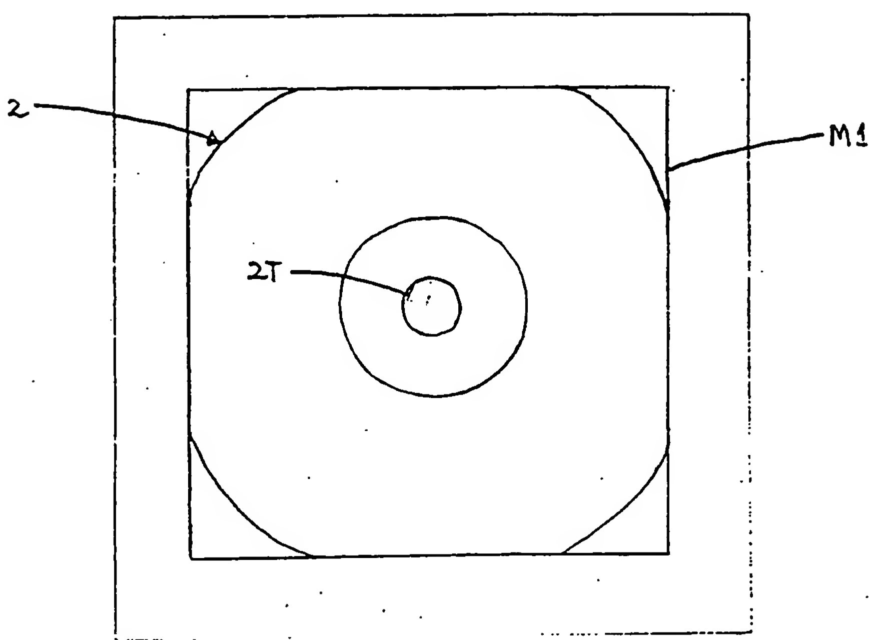


FIGURE 2B
(DETAIL A)

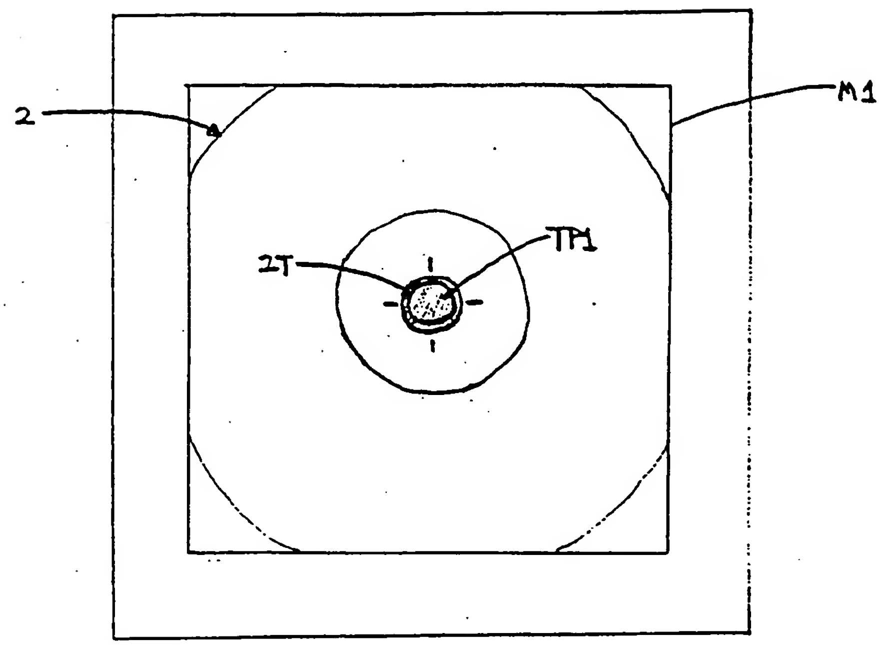


FIGURE 2C
(DETAIL A)

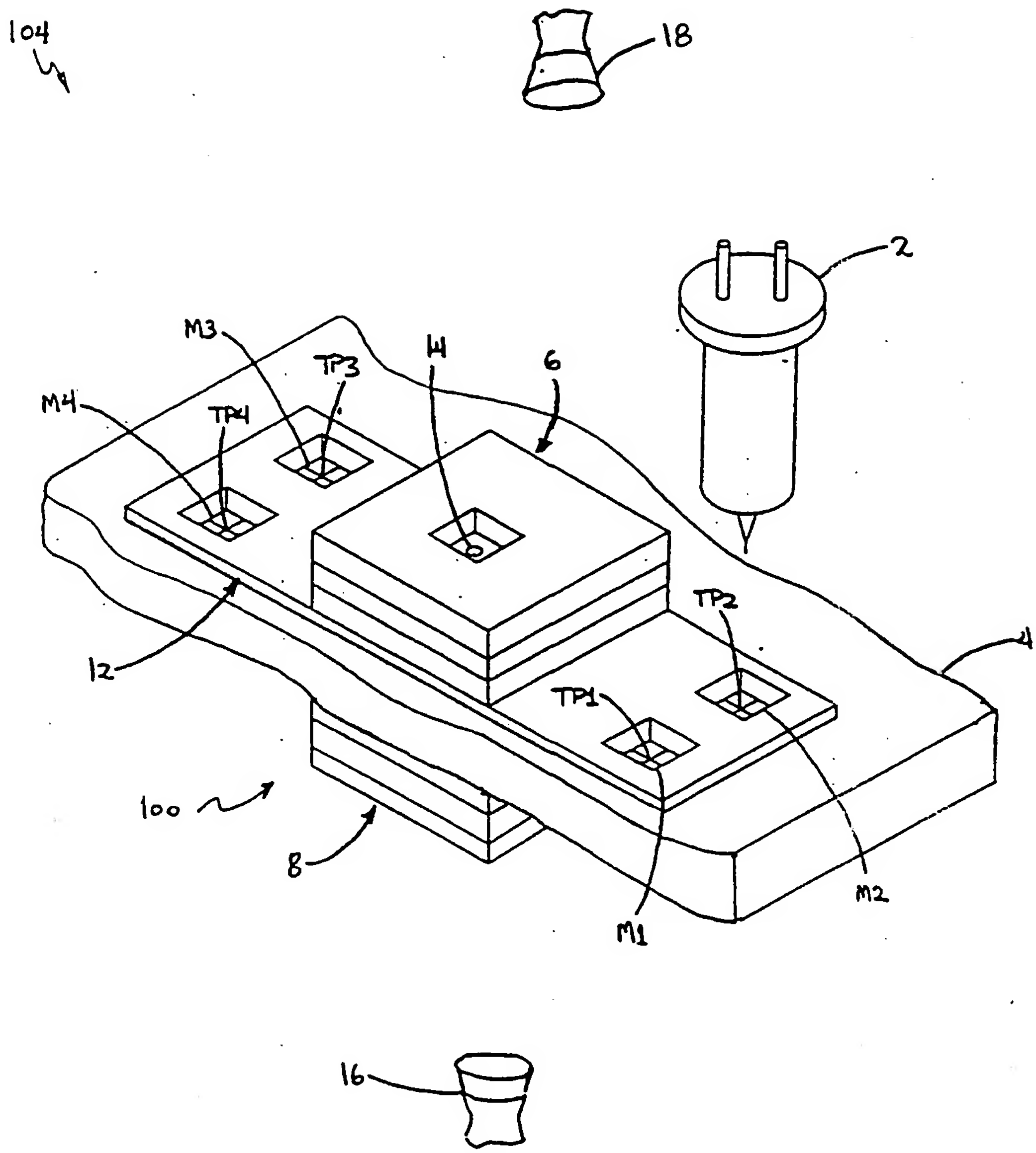


Figure 3

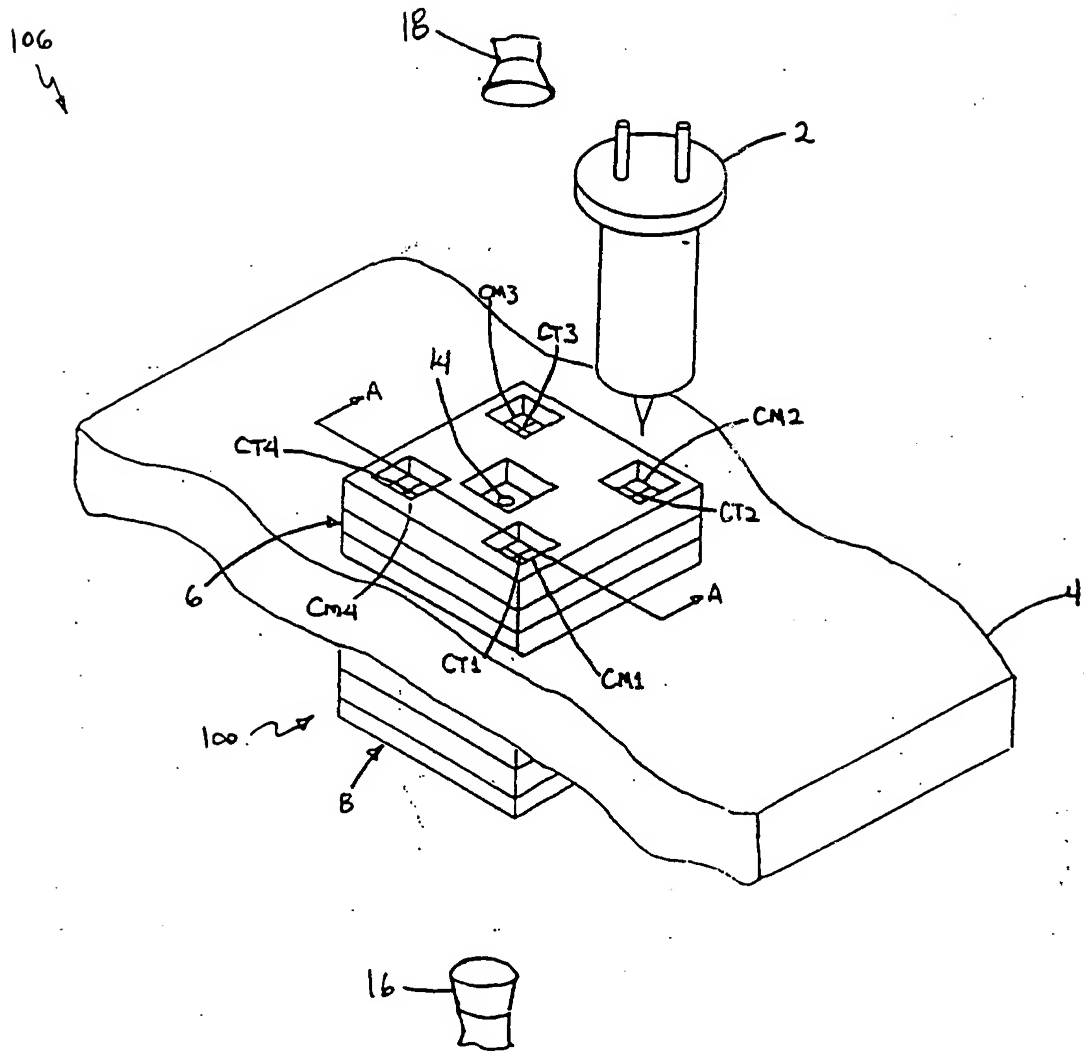


FIGURE 4

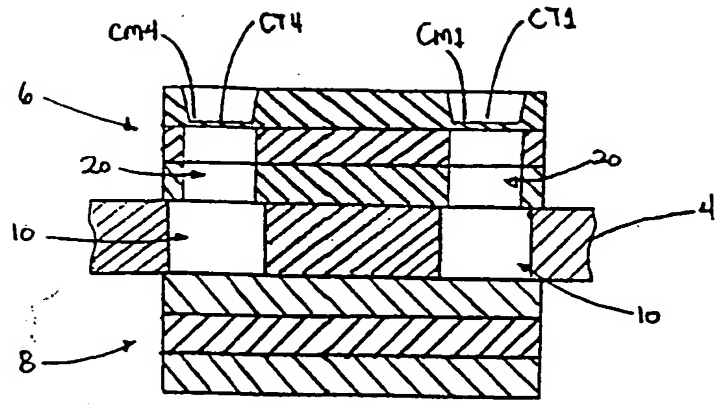


FIGURE 5A
(CROSS-SECTION A-A)

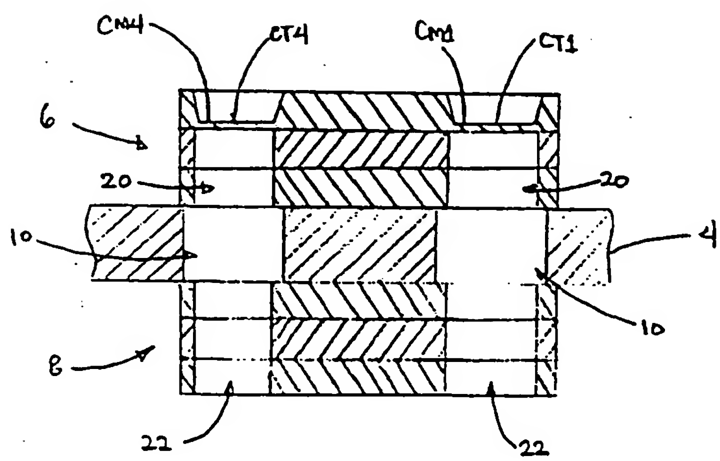


FIGURE 5B
(CROSS-SECTION A-A)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/23500

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01J37/04 H01J9/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DESPONT M ET AL: "Microfabrication of Lenses for a Miniaturized Electron Column" MICROELECTRONIC ENGINEERING,NL,ELSEVIER PUBLISHERS BV., AMSTERDAM, vol. 27, no. 1, 1 February 1995 (1995-02-01), pages 467-470, XP004025123 ISSN: 0167-9317 page 469, right-hand column, paragraph 2 -page 470, left-hand column, paragraph 2; figures 4,5 ---	1,18,23, 29,34

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2000	20/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schaub, G

1

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	CHANG T H P ET AL: "ELECTRON-BEAM MICROCOLUMNS FOR LITHOGRAPHY AND RELATED APPLICATIONS" JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY, B, vol. 14, no. 6, November 1996 (1996-11), pages 3774-3781, XP000957961 cited in the application page 3777, right-hand column, paragraph 3 -page 3778, left-hand column, paragraph 2; figure 5	1,18,23, 29,34
P,A	WO 00 46831 A (ETEC SYSTEMS INC) 10 August 2000 (2000-08-10) the whole document	1,18,23, 29,34

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern ial Application No

PCT/US 00/23500

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0046831 A	10-08-2000	NONE	